WESTERN
CONNECTICUT
STATE UNIVERSITY

February 2, 2015

Dear Chairs and Members of the Committee on Children:

I am writing in support of Raised Bill No. 207, AN ACT CONCERNING FUNDING FOR A LYME DISEASE PREVENTION AND EDUCATION PROGRAM. Awarding $450,000 to implement and sustain a statewide Lyme disease prevention effort will be a wonderful step towards addressing a major public health issue in our state. I am a researcher who has been studying the prevention of Lyme disease since 1998. I live and work in Lyme-endemic Connecticut. I believe that more tick-borne disease prevention education is greatly needed in our state.

Lyme disease and other tick-borne diseases are a major public health concern in the northeastern United States. Connecticut is among the top states reporting cases of Lyme disease, primarily because its residents live and recreate in very close proximity to blacklegged ticks. Many people are unaware that the highest risk for Lyme disease occurs in one's own backyard. In addition, they do not know that children under the age of 10 are among those at the greatest risk for contracting the disease. Sadly, the research shows that most people do not consider taking Lyme disease prevention precautions until after a family member has already become sick. The same tick that carries and transmits the organism that causes Lyme disease can also transmit several other disease-causing agents that can be debilitating and even fatal to humans. There is no vaccine currently available for any of these ailments. To complicate matters, the diagnosis of Lyme disease is sometimes challenging and controversial. Some people who become sick from tick-borne illnesses suffer long-term effects, which come at a great economic burden to society. Therefore, the successful prevention of Lyme and other tick-borne diseases is crucially important to protecting the health of Connecticut residents.

Working with a team of researchers at Yale Emerging Infections Program, the Connecticut Department of Public Health, and the Centers for Disease Control and Prevention, we conducted a three-year study here in Connecticut that investigated the most effective practices for preventing Lyme disease in our residents. The results of that study were published in the Journal of Preventive Medicine in 2009 (attached). However, there is a great need to disseminate these and other scientific findings into the public realm so that we can have an impact on human health.

The BLAST program, started by the Ridgefield Health Department, promotes not only the protective measures we identified in our 2009 study, but also other prevention measures that are supported by the scientific literature. I have served as a scientific advisor to the BLAST program since its conception. I have seen BLAST program staff working in the community at health fairs and other events. The public response to their presence has been impressive. Connecticut residents are eager for prevention information. I believe the BLAST program does an excellent job at educating the public.

A commitment of state funds to implement and sustain a statewide tick-borne disease prevention program using the BLAST model would benefit the health of Connecticut residents. I am in support of Raised Bill No. 207.

Best Regards,

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Peridomestic Lyme Disease Prevention
Results of a Population-Based Case–Control Study

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Background: Peridomestic Lyme disease–prevention initiatives promote personal protection, landscape modification, and chemical control.

Purpose: A 32-month prospective age- and neighborhood-matched case–control study was conducted in Connecticut to evaluate the effects of peridomestic prevention measures on risk of Lyme disease.

Methods: The study was conducted in 24 disease-endemic Connecticut communities from 2005 to 2007. Subjects were interviewed by telephone using a questionnaire designed to elicit disease-prevention measures during the month prior to the case onset of erythema migrans. Data were analyzed in 2008 by conditional logistic regression. Potential confounders, such as occupational/recreational exposures, were examined.

Results: Between April 2005 and November 2007, interviews were conducted with 364 participants with Lyme disease, and 349 (96%) were matched with a suitable control. Checking for ticks within 36 hours of spending time in the yard at home was protective against Lyme disease (OR=0.55; 95% CI=0.32, 0.94). Bathing within 2 hours after spending time in the yard was also protective (OR=0.42; 95% CI=0.23, 0.78). Fencing of any type or height in the yard, whether it was contiguous or not, was protective (OR=0.54; 95% CI=0.33, 0.90). No other landscape modifications or features were significantly protective against Lyme disease.

Conclusions: The results of this study suggest that practical activities such as checking for ticks and bathing after spending time in the yard may reduce the risk of Lyme disease in regions where peridomestic risk is high. Fencing did appear to protect against infection, but the mechanism of its protection is unclear.
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Introduction

The highest risk for Lyme disease in the northeastern U.S. occurs in the peridomestic environment.[1–3] Efforts to prevent infection, in the absence of a vaccine, have focused primarily on preventing exposure to the tick vector *Ixodes scapularis* (commonly known as blacklegged ticks or deer ticks). Recommended peridomestic prevention measures promote three strategies: personal protection, landscape intervention, and chemical control.[4]

Personal protective measures include performing tick checks (i.e., inspecting body parts for ticks) and wearing protective clothing. Landscape interventions that seek to create an inhospitable environment for ticks and their hosts, while maintaining a safe zone for recreation, include creating a dry barrier of gravel or mulch between lawn and woods or installing deer-exclusion fencing. Chemical control measures include spraying acaricide to reduce the number of ticks in the yard at home.

Several studies have identified a number of peridomestic risk factors for Lyme disease.[2,5–11] However, few have examined the effectiveness of recommended Lyme disease–prevention measures, and these have produced conflicting results. One study[8] showed no significant differences in personal protective measures taken by Lyme disease cases versus their age-matched controls. In contrast, another study[10] found that people who applied repellent before going outdoors or routinely checked for ticks while outdoors were less likely to get Lyme disease. However, checking for ticks after coming in from being outdoors was not shown to be protective against Lyme disease. Data from another study[12] indicated that wearing protective clothing or repellent was more commonly practiced among people who did not have Lyme disease. Although chemical

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control measures are effective at reducing the number of infected ticks in the peridomestic environment,[10,13–15] it is unknown if these measures reduce disease risk. In fact, the effectiveness of any Lyme disease–prevention measure taken specifically in the peridomestic environment has not been examined in detail. Accordingly, a case–control study was conducted to evaluate the effectiveness of recommended measures for preventing Lyme disease peridomestically.

Methods

Study Population

A 32-month, population-based, 1:1 age- and neighborhood-matched Lyme disease case–control study was conducted in 24 Connecticut towns where Lyme disease is endemic. The study towns were located within three health districts in Fairfield, Litchfield, and New London counties. During the study period, these counties reported a mean incidence of 47, 189, and 133 cases per 100,000 population, respectively. These health districts have had ongoing Lyme disease education programs in place since 2000. It is likely that residents of the towns had some exposure to disease-prevention education.

Cases were identified from Lyme disease reports submitted to the Connecticut Department of Public Health. Cases were defined strictly as those living in the study area with an onset date falling between April 2005 and November 2007, and with physician-diagnosed EM to identify incident cases. To enroll cases, attempts were made to reach them by telephone a minimum of 15 times within a 3-month period from the reported EM onset date. Once a case was enrolled, subsequent cases from that address were ineligible.

Risk for exposure to blacklegged ticks varies greatly by landscape.[16] To minimize ecologic variability between case and control residences, a neighborhood-matched control was sought for each enrolled case. In addition, Lyme disease risk is age-related, with most cases reported from children and middle-aged adults.[8,10,17,18] Therefore, case–control pairs were also matched by age using four age groups: 1–10 years, 11–17 years, 18–49 years, and ≥50 years. Telephone numbers for potential controls were identified using a spatially explicit telephone database (InfoUSA, Omaha NE). Unlisted telephone numbers, cell phone numbers, and voice-over Internet protocol numbers were not included in the database. A search was done for residential telephone numbers within 0.2 mile–increments around the case address until at least 30 numbers were compiled. Phone numbers were called randomly until an age-matched individual, with no history of Lyme disease during the current year, was enrolled. All case and control subjects had to have lived on a property with a yard, and a resident of the household had to have been responsible for the yard maintenance decisions.

Data Collection

Subjects were interviewed by telephone about peridomestic Lyme disease–prevention measures by trained interviewers using a standardized questionnaire. As often as possible, the same person interviewed both the case and its matched control. Interviews occurred within 3 months of the case's EM onset, in order to minimize recall error. Because EM typically appears within 3–30 days after infection, subjects were asked about the frequency of the prevention measures taken in the month prior to the onset of EM. The questionnaire was used to measure landscape features, chemical control practices, personal protective behaviors, and possible confounders (Table 1; Appendix A, available online at www.ajpm-online.net). A parent was interviewed as a proxy for minors. Verbal consent was obtained from each participant before administering the questionnaire. This study was approved by the Human Investigations Committees at the Yale University School of Medicine and the Connecticut Department of Public Health.

Statistical Analysis

The number of matched pairs required for this study was calculated to detect an OR of 0.5 given a 0.05 significance level, 0.80 power, and a 0.20 correlation between case and control exposure status using PS Power and Sample Size Calculations Software.[19] The correlation estimate of 0.20 was based on recommendations suggested previously.[20] Assuming that outdoor repellent use among controls would be 25%, 256 matched case–control pairs were required to detect an OR of 0.5 for using repellent. A total of 349 matched pairs were analyzed. Data were analyzed in 2008 using SAS version

Table 1. Variables measured in a peridomestic Lyme disease–prevention case–control study

Landscape features/modifications	**Potential confounders**
Mowing frequency[a]	Presence of woods in or adjacent to yard
Branch trimming[b]	Pet or livestock ownership
Leaf-litter clearing[b]	History of travel to tick-endemic areas
Use of a birdfeeder (April–October)	Recreational exposure to ticks (outside of yard)
Presence of a vegetable garden in yard	Amount of time spent in the yard
Presence of recreational areas (e.g., playscapes)	Occupational exposure to ticks
Presence of a stone wall or log pile	Use of prophylactic antibiotic therapy after recognized tick bite
Presence of fencing around the property	Gender
Presence of a mulch or gravel dry barrier where lawn met woods	History of Lyme disease
Personal protection[b]	**Chemical control measures**
Performing tick checks	Acaricide and other pesticide use
Wearing long pants and/or light-colored clothes	Rodent-targeted tick-control device use[c]
Bathing after spending time outdoors	
Tucking pants into socks	
Wearing repellent	
Wearing clothing treated with permethrin insecticide	

[a]The number of times the lawn was mowed during the month prior to erythema migrans onset
[b]Measured whether the activity was practiced during the month prior to erythema migrans onset
[c]Includes fipronil bait boxes or tubes containing permethrin insecticide-treated cotton

9.1. Conditional logistic regression analyses were performed to calculate ORs and 95% CIs associated with prevention measures in matched case–control pairs.[21] Variables with $p<0.20$ in the univariate analysis and that were biologically plausible were included in the multivariate analysis.[22,23] Backward elimination was used to arrive at the most parsimonious final model. Variables that were significant in the univariate analysis but had too few observations for evaluation were not entered in the final model. Several questions were designed to gauge frequency of a behavior. However, most preventive behaviors, when practiced at all, were not performed frequently. Therefore, the responses to frequency-based questions were dichotomized, comparing "never" to all other categories.

Results

Study Population

During the study period, 927 EM cases were reported from the 24-town area. The median age for cases reported was 49 years (range: 1–95 years); 29% of reported cases were aged <18 years, and 42% were aged 41–60 years. EM onset occurred most frequently during the months of June (32%) and July (38%). A total of 706 cases (76%) were called, and 485 (52%) were reached within 3 months. There were 221 cases that were not contacted; 125 cases (13%) were missing pertinent data on their report forms (age, onset date, or contact information); 51 (6%) were received by our office beyond the requisite 3-month period; 22 cases (2%) were enrolled (or someone in that patient's household was enrolled) during a previous study year; in 13 cases (1%), the reporting physician requested that the case not be contacted; and 10 (1%) cases lived at known apartment complexes without yards.

Of the 485 cases reached by telephone, 69 (14%) refused to participate; 21 (4%) did not make yard maintenance decisions; 11 (2%) claimed not to have had Lyme disease; 7 (1%) did not have a yard; 7 (1%) were ineligible due to physical/mental impairment or language barrier; and 6 (1%) did not live in the study area. A total of 364 cases (75%) were enrolled. The proportion of cases enrolled from each health district was similar to the proportion of EM cases reported to the state health department from each district. A control subject was enrolled for 349 (96%) of the enrolled cases. A total of 127 control subjects (36%) lived <0.2 miles from their matched cases; 109 controls (67%) lived within 0.4 miles; 57 controls (83%) lived within 0.6 miles; 27 controls (92%) lived within 0.8 miles; and 29 controls (100%) lived within 2 miles of their matched case subjects. A total of 100% of enrolled minor controls and 62% of adult controls were matched within 10 years of the case age. Cases and controls were demographically similar, except that control subjects were significantly more likely to be women.

Univariate Analysis

Univariate analysis of matched case–control pairs indicated that control subjects were significantly more likely to perform tick checks within 36 hours (OR=0.64; CI=0.43, 0.94) and to bathe within 2 hours (OR=0.60; CI=0.38, 0.96) after spending time in the yard. No significant differences between cases and controls were found regarding the following personal protective measures: wearing long pants, wearing light-colored clothing, and using repellent. No significant differences were found between cases and controls with respect to the following landscape features or chemical measures: mowing frequently, trimming branches, clearing leaf litter, using birdfeeders, having a vegetable garden, having a stone wall or log pile, having a fence around the property, having a dry barrier, and spraying pesticides (Table 2). The effectiveness of several prevention measures could not be evaluated, since infrequent practice made it difficult to ascertain differences between case behavior and control behavior (Table 3). These measures were not included in the univariate analysis.

Multivariate Analysis

Six variables were included in the final model (Table 4). All possible interactions between variables were examined, and no significant interaction terms were found. Performing tick checks within 36 hours after spending time in the yard (OR=0.55; CI=0.32, 0.94) and bathing within 2 hours after spending time in the yard (OR=0.42; CI=0.23, 0.78) remained significantly protective, and having a fence on the property (OR=0.54; CI=0.33, 0.90) was also protective against Lyme disease. Wearing repellent when out in the yard at home also appeared to be protective; however, this finding did not reach significance (OR=0.59; CI=0.35, 1.03).

Discussion

Two personal measures were observed to be protective against Lyme disease: performing tick checks and bathing shortly after spending time outdoors. Because studies[24,25] have demonstrated that it takes more than 24 hours for blacklegged ticks to transmit the etiologic agent, prompt removal of ticks found attached to the body is a logical method of Lyme disease prevention. The effectiveness of performing tick checks has been suggested previously[8,10]; however, this is the first time it has been demonstrated in a peridomestic setting. Frequent bathing is not a commonly recommended Lyme disease–prevention measure. Although it is unlikely that bathing will remove ticks that have attached to the body, taking a shower or bath soon after spending time outside may remove ticks that are yet unattached, or may create an opportunity to find ticks on the body. In

Table 2. Univariate conditional logistic regression analyses of Lyme disease–prevention measures taken by case–control subjects

	n[a]	% cases	% controls	Matched p-value	OR	95% CI
Personal protective measures						
Performed tick checks within 36 hours after spending time in the yard	617	57	65	0.02	0.64	0.43, 0.94
Bathed within 2 hours after spending time in the yard	592	77	85	0.03	0.60	0.38, 0.96
Wore repellent while in the yard	617	33	41	0.07	0.71	0.49, 1.02
Wore light-colored clothing while in the yard	570	88	90	>0.20		
Wore long pants while in the yard	614	65	70	>0.20		
Landscape features/modifications						
Mowed lawn 3 or more times in the month prior to erythema migrans rash onset	686	79	73	0.07	1.43	0.97, 2.11
Used a birdfeeder (April–October)	695	55	49	0.14	1.29	0.92, 1.80
Had woods adjacent to property	693	52	48	0.17	1.32	0.89, 1.98
Had a vegetable garden	697	36	31	0.07	1.36	0.97, 1.91
Had a fence on the property (any type)	697	38	44	0.14	0.79	0.58, 1.08
Had a stone wall	689	60	61	>0.20		
Had a log pile in the yard	695	53	50	>0.20		
Trimmed branches back where lawn met woods[b]	522	83	85	>0.20		
Cleared leaf litter from where lawn met woods[b]	523	54	46	>0.20		
Had a dry barrier where lawn met woods[b]	524	12	16	>0.20		
Chemical control measures						
Sprayed acaricide during the past 2 years	454	10	12	>0.20		
Used pesticides for pests other than ticks	673	23	26	>0.20		

[a]Sample size was affected if subjects refused to answer or did not know the answer to the question. Subjects may have performed more than one preventive measure.
[b]Includes only subjects that had woods adjacent to their properties.

addition, the act of bathing may indirectly prevent tick bites in that it necessitates the removal of clothing that may be carrying blacklegged ticks.

The current data also suggest that the use of insect repellent may be protective, although this result was not significant. This finding applies to all reported repellents including those that may not contain N,N-diethyl-3-methyltoluamide (DEET), but it does not include permethrin insecticide applied to clothing, which occurred infrequently. The effectiveness of insect repellents has been shown previously,[10,12] but not in the peridomestic environment. Promoting tick checks, bathing, and using insect repellent as a part of future Lyme disease–prevention efforts may be successful, because people living in disease-endemic areas perceive these prevention measures as effective and easy to practice.[26]

Other personal protective measures, such as wearing long pants and light-colored clothing, did not appear to effectively reduce Lyme disease risk. Results of previous studies have yielded varying results with regard to the effectiveness of protective clothing,[10,12] as well as the perceived effectiveness of various prevention measures.[27] Further, it has been found[28] that 46% of surveyed Connecticut residents reported using personal protective measures when spending time outdoors, but that residents were less likely to employ these measures within their own yards. Residents may purposely not wear protective clothing or utilize other protective practices when spending time in the yard because of a perception that the highest risk for tick exposure is found when engaging in outdoor activities outside of the yard.

Surprisingly, the presence of any type of fence, including short fences, those that do not entirely enclose the yard, and those that may fail to block access for host animals (e.g., split-rail fences), appeared to be associated with a reduced risk for disease. It may be that the presence of any barrier may be sufficient to reduce the number of white-tailed deer visiting the property. Alternatively, a fence might keep people away from wooded areas, thus lowering the risk of tick exposure.

Table 3. Infrequently practiced Lyme disease–prevention measures among case–control study subjects

	n	% cases	% controls
Wore clothing treated with permethrin insecticide	587	0.7	0.7
Used rodent-targeted tick-control devices	688	3	2
Received prophylactic antibiotic therapy after tick bite	156	4	6
Had deer-exclusion fencing around property	697	6	7
Tucked pants into socks	421	8	10

[a]Sample size was affected if subjects refused to answer or did not know the answer to the question. Subjects may have performed more than one preventive measure.

Table 4. Multivariate conditional logistic regression analyses of Lyme disease–prevention measures taken by case–control study subjects[a]

	Adjusted OR (95% CI)
Personal protective measures	
Performed tick checks within 36 hours after spending time in the yard	0.55 (0.32, 0.94)
Bathed within 2 hours after spending time in the yard	0.42 (0.23, 0.78)
Wore repellent when spending time in the yard	0.59 (0.35, 1.03)
Landscape features/modifications	
Had a fence on the property	0.54 (0.33, 0.90)
Had woods adjacent to yard	1.53 (0.79, 2.95)
Confounders[b]	
Had an occupational exposure to ticks	1.72 (0.84, 3.54)

[a]Table depicts results of the final multivariate model. The initial multivariate model also included the following variables that were removed by backward elimination: presence of a vegetable garden, birdfeeder use, frequent lawn mowing, cat ownership, and gender.
[b]Depicts risk factors and other potentially confounding variables listed in Table 1 that remained in the multivariate analysis after backward elimination.

However, there may be factors contributing to this result that were not measured. More data are needed to further evaluate this finding.

The current results did not support those hypothetically protective measures that were infrequently practiced within the study population or were routinely practiced by both cases and controls. Further study of these variables may be warranted in order to examine why these measures are or are not adopted by the public and whether, if used, they could be effective in reducing risk for Lyme disease.

The current analysis was based on self-reported data, which have various inherent limitations. Because most variables measured in this study were behavioral, there is no alternative assessment method. Additionally, interviewers were aware of the case/control status of the enrollees. This knowledge is a source of potential observer bias. However, all interviewers were trained to administer the questionnaire in a standard manner. Further, it is possible that cases were more likely than controls to recall behaviors that may have led them into contact with ticks because their diagnosis could have caused them to contemplate such factors. Interviews were completed within 3 months of EM onset to minimize lapses in recall of prevention measures.

The study design precluded the researchers contacting potential controls who did not have landline telephones or who maintained unlisted numbers. Cases were not subject to this limitation. This difference could have introduced selection bias if people without a listed landline telephone number differ systematically with regard to their Lyme disease–prevention practices or their peridomestic landscape.

Neighborhood matching was conducted to minimize variation in environmental characteristics surrounding subject homes. However, research indicates that tick densities can vary greatly at a fine scale.[29] Case–control pairs in the current study generally lived close to one another, but entomologic and landscape factors were not measured directly. Therefore, it is not known whether case and control properties had similar tick densities. Environmental variation that remained after the neighborhood matching process could have resulted in an underestimation of the protective effect of measures taken to prevent infection, because people who live in environments with high tick densities may be more likely to practice protective behaviors.

Further, even though Lyme disease risk may be peridomestic, residents of Lyme disease–endemic areas may be exposed to blacklegged ticks in other outdoor environments where they have no control over the landscape. Therefore, making landscape modifications or using chemical control within the yard at home may not necessarily reduce true risk of exposure.

This study sought to evaluate the effectiveness of recommended peridomestic Lyme disease–prevention measures. The findings emphasize the need to promote personal protection measures to reduce the risk of Lyme disease. It is encouraging that the identified protective measures—checking for ticks, bathing, and possibly using repellent—are inexpensive enough that anyone can use them to reduce their risk, and not only peridomestically. The findings also suggest that fencing may protect against infection, but because this included any and all fencing, further study is needed to clarify what aspect of fencing is protective. Health practitioners in Lyme disease–endemic areas should educate the public about these simple, practical methods for reducing peridomestic Lyme disease exposure.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amepre.2009.04.026.